REPORT OF COOPERATIVE RESEARCH ON INSECT CONTROL IN FARM STORED GRAIN

No. 8 Period--April 1 to June 30, 1943

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The material in this report consists largely of unpublished data ~~and should be kept confidential~~. It is made available in its present form for the convenience of the various State and Federal Agencies concerned with the preservation of stored grain from insect damage.

CORN STORAGE

Condition of Corn at Experimental Bin Sites***

During the latter part of March and early in April, observations were made in all of the experimental corn bins in the several localities in Iowa, Minnesota, South Dakota, and Nebraska. In general, there has been but little change in the condition of the shelled corn stored in these bins since the last observations were made in October and November, 1942. Moisture content in the surface layer of grain was somewhat higher than in the fall, and insect populations were lower. A summary of the temperatures and insect populations is presented in table 1. The average temperatures in the centers of the bins varied from a low of 28° F. in Nicollet County, Minnesota, in the northern part of the region, to a high of 41° F. in several of the localities in the southern part of the region. The average infestation per 1,000 grams varied from zero in Roberts County, South Dak., to 18.6 insects per 1,000 grams in Cerro Gordo County, Iowa. The high survival at the latter locality is of considerable interest, since it is located in northern Iowa, where winter temperatures are expected to reduce insect populations to a very low point.

Table 1:--Summary of temperatures and insect infestation in shelled corn stored in steel bins in S. Dakota, Minnesota, Nebr., and Iowa, Spring, 1943

State	County	Number of bins	Temperature Vertical column center of bin			Infestation (Insects per 1,000 grams) (Average)
			Maximum	Minimum	Mean*	
S. Dak.	Roberts	3	42	19	29	0
	Minnehaha	3	50	27	33	6.8
Minn.	Yellow Medicine	8	41	17	29	0.5
	Nicollet	5	35	19	28	4.5
Nebr.	Antelope	8	56	32	38	0.7
	Richardson	6	62	35	41	2.7
Iowa	Osceola	6	47	26	33	1.9
	Cerro Gordo	6	55	28	36	18.6
	Boone	10				7.8
	Story	5				0.4
	Henry	11	46	32	38	0.4
	Montgomery	6	50	34	38	9.6
Ill.**	Champaign	6	67	33	41	5.1
	Iroquois	26	61	30	40	11.3
	McLean	15	50	35	41	9.2
	Whiteside	16	60	30	40	16.5
	LaSalle	7	68	30	41	6.5

* Average of five readings, taken at floor, 3', 6', 9', and 12' levels in 2740-bushel bins and at floor, 3', 6', and 9' levels in 2000-bushel bins.

** From observations made by M. D. Farrar and J. M. Wright.

*** Reported by H. H. Walkden in cooperation with the Bureau of Agricultural Chemistry and Engineering and the Iowa Experiment Station.

Corn Storage in Illinois*

At the request of the Illinois State AAA Committee, two entire bin sites and parts of two others were released. These sites were Loda, eight bins, and Cissna Park, six bins, in Iroquois County, entirely disbanded, and six bins at Tomlinson, Champaign County and four bins at Shirley, McLean County. This released all 2000 bushel bins filled in 1940 in the experimental program. The 2000 bushel bins at Rock Falls, Whiteside County will be released approximately August 15. The lease on the bin site is not to be renewed and final observations will be made prior to that date, at which time the corn is to be shipped out. This will leave twenty-two 2740 bushel bins and twenty-six 2000 bushel experimental bins.

Insect Infestation

The flat grain beetle, Laemophloeus minutus, survived the winter in the greatest numbers and continued to be the most abundant species in Illinois experimental corn bins during the quarter. It was followed in order by the sawtoothed grain beetle, Oryzaephilus surinamensis, the rust-red flour beetle, Tribolium castaneum, Cynaeus angustus, Typhaea stercorea, and the cadelle. The populations were still fairly low although they are beginning to build up as evidenced by the increasing numbers of larvae taken in the insect samples. Cynaeus angustus was again recovered from northern bins only. Adult Indian meal moths are becoming increasingly abundant in the corn bins although they were not recovered from the probe samples.

Winter mortality was high in the northern bins. From 200 to 300 dead insects, mostly Tribolium castaneum, have been found in the regular 6-probe samples from bins in Whiteside County and fewer dead insects were found in the more southerly bins.

Temperature

Bin temperatures reached their lowest points in mid-April and are now rising with the advent of hot weather. Late in the quarter temperatures were mostly in the high forties and fifties with the top layers of corn in most bins going as high as 70 to 80 degrees. Considerable interest attaches to Bin 104 at Thomasboro, Champaign County. Due to the heavy rains of early May this bin was flooded to a depth of about three inches and in 19 days the temperatures on the floor had risen approximately 40 degrees (see table 2). Temperatures above the floor had not risen abnormally, however, and frequent observations will be made in this bin.

Moisture

With the advent of hot weather the surface moisture decreased, most of them now being from 12.00 to 15.00 percent. Moist moldy areas which occurred on the surfaces of many bins have for the most part dried leaving spots of dry but somewhat damaged corn. This does not amount to over a few bushels per bin.

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* Reported by J. M. Wright in cooperation with Dr. M. D. Farrar, Research Entomologist, Illinois State Natural History Survey.

Table 2:--Temperature readings on floor of bin 104, Thomasboro, Illinois, May 5 to June 9, 1943.

Location of thermocouple	Temperature		
	May 5, 1943	May 21, 1943	June 9, 1943
	(°F)	(°F)	(°F)
Center	46	50	94
Three feet north center	46	49	88
Six feet north center	46	51	83
Three feet east center	48	56	92
Six feet east center	51	55	78
Three feet south center	48	54	85
Six feet south center	51	54	84
Three feet west center	48	52	87
Six feet west center	51	52	79

Soybean Storage

Due to a shortage of seed beans, 2000 bushel bins 305, 306, and 307 at Bongard, Champaign County were released to the Commodity Credit Corp.

Insect Infestation

Three experimental bins, numbers 632 at Savoy, Champaign County, 96 at Prophetstown and 634 at Lyndon, Whiteside County were slightly infested with insects. Bin 632 at Savoy had one Tribolium castaneum, bin 96 at Prophetstown had one Cynaeus angustus, and bin 634 at Lyndon had three Cynaeus angustus and three flat grain beetles recovered from regular 6-probe center samples. Bin 634 at Lyndon is heating and the beans are molding badly in the top 30 inches and although the insect population is at present low, it is expected that it will increase.

Temperature

Temperatures in soybean bins are still fairly low, being mostly in the fifties and low sixties. Because of the hot weather surface temperatures are high running from the high seventies to the low nineties with a few even higher. Bin 634 at Lyndon is heating and the top 30 inches of beans are badly molded. The temperatures from April 27, 1943 to June 18, 1943 are given in table 3. Temperatures of bin 636 at Lyndon are also given for comparison. These beans were immature and partially frost-damaged when they were put in the bin.

Moisture

Moisture contents are generally very low, mostly 11.00 to 14.00 percent with few being higher and some as low as 9.00 percent. Observations in the western and northern parts of the state show that there has been a decrease of five to 10 percent in surface moistures in some bins since the early part of the quarter.

Germination

One set of germination samples from every bin has been tested and another is being germinated at the present time by the Illinois Agricultural Experiment Station. Germinations ranged from 26 to 99 percent with the bulk of the samples testing in the seventies to nineties. Beans stored in Champaign, Iroquois, Wabash, and Saline Counties tested highest. These beans were mature and harvested before the frost of last fall.

Table 3:--Temperatures of bins 634 and 636 at Lyndon, Whiteside County, Illinois, April 27, 1943 to June 18, 1943.

Bin number	Date	Temperatures in Degrees Fahrenheit				
		Floor	3 feet*	6 feet	9 feet	12 feet
634	4/27/43	41	37	37	54	80
636	"	41	37	37	40	62
634	5/25/43	43	36	41	66	68
636	"	43	35	36	45	57
634	6/18/43	47	42	52	79	97
636	"	49	42	47	59	90

* Distance above floor.

Commercial Grade

Testing of samples taken from all bins during March and sent to the Board of Review in Chicago has been completed aand the results are shown in table 4. As can be seen, most of the low grades obtained were because of the large amounts of damaged beans. No report has reached this laboratory of the samples sent to Washington, D. C. for further chemical tests.

Table 4:--Commercial grade and the determining factors for soybeans in experimental bins as of March, 1943*

County	Bin site	Bin number	Grade	Test wgt.	Moist.	Dockage	Total damage	Splits	Foreign material
Champaign	Savoy	629	2Y	56.5	12.0		1.9	11.0	trace
		630	2Y	55.5	12.0	1.0	2.8	8.0	
		631	2Y	56.5	10.4	1.0	2.5	6.7	0.8
		632	1Y	56.5	10.5	1.0	1.4	9.4	1.0
		633	2Y	56.0	11.2	2.0	2.3	5.2	0.3
		634	2Y	56.5	10.5	1.0	2.9	5.5	0.1
	Pauline	57	3Y	55.0	11.6	2.0	3.7	11.0	
		58	2Y	55.5	12.5	2.0	3.0	7.2	0.1
		59	2Y	55.0	12.6	1.0	2.3	11.0	0.4
		60	2Y	54.5	13.0	3.0	2.0	15.0	0.2
		63	3Y	53.8	13.4	4.0	4.2	18.9	0.1
		297	2Y	55.0	13.5	1.0	2.0	6.3	0.2
Iroquois	Goodwine	28	3Y	55.5	12.4	4.0	4.6	12.0	0.4
		454	2Y	56.5	11.3	1.0	2.9	9.1	1.0
		455	2Y	57.0	11.4	3.0	2.4	13.2	0.4
		603	2Y	56.0	11.3	1.0	2.0	15.0	0.2
		609	3Y	55.5	11.7	2.0	3.6	9.7	0.3
		611	3Y	56.0	12.1		3.3	11.5	
LaSalle	Troy Grove	615	3Y	54.0	12.3	5.0	5.0	19.3	0.3
		616	SG	53.5	12.1	1.0	8.8	15.0	0.8
		617	4Y	54.0	12.7	3.0	8.0	13.1	0.1
McLean	Stanford	2261	SG	55.5	12.6	1.0	9.0	10.4	0.2
		2263	4Y	54.5	12.5	1.0	6.0	10.9	0.1
		2264	SG	55.0	13.5	2.0	9.0	13.0	0.4
	Randolph	480	3Y	56.0	11.0	2.0	4.3	8.4	0.6
		481	3Y	56.0	11.6		5.0	6.6	0.3
		482	4Y	56.0	11.9	1.0	7.8	6.0	trace
McDonough	Macomb	57	SG	55.5	12.1	1.0	12.0	9.5	0.9
		227	4Y	55.0	13.0	1.0	8.0	11.0	
		229	SG	55.5	12.5	1.0	15.0	9.2	0.6
		357	SG	55.0	11.7	2.0	9.0	16.0	0.4
		358	4Y	55.0	12.1	1.0	7.9	13.4	1.2
		359	SG	55.5	12.0	2.0	18.0	12.0	0.3
Saline	Harrisburg	18	SG	55.5	8.4	3.0	2.6	8.0	6.8
		19	2B	56.0	8.4	1.0	0.6	2.0	1.5
Wabash	Bellmont	16	1B	56.5	9.4		1.3	2.7	0.4
		17	1B	56.0	9.5		1.2	1.6	0.2
		18	1B	56.0	9.9		1.1	5.2	1.0
Whiteside	Prophets-town	96	SG	55.5	12.0		16.5	6.8	0.3
		97	SG	54.0	13.3	1.0	25.0	12.6	0.5
		98	SG	55.5	11.6		17.7	6.0	trace
	Lyndon	632	SG	53.5	16.1	2.0	19.0	11.0	0.3
		634	SG	52.5	16.0	1.0	31.5	7.0	
		636	SG	54.0	14.0		27.0	10.6	0.4

* Samples tested by the Board of Review, Chicago, Illinois.

WHEAT STORAGE

Condition of Wheat in Storage at Experimental Plots*

During April and May, the regular quarterly samples were taken from the bins on the experimental storage sites at both Jamestown, North Dakota, and Hutchinson, Kansas. Insect infestation was determined from the examination of average samples taken from each bin.

Insect population at Jamestown remains at a very low point. Out of a total of 162 bins sampled, only one flat grain beetle was found in one of the bins, and mites were noted in seven bins.

At Hutchinson, out of 148 bins sampled, 26 percent were found to be infested, 5 percent grading weevily, as compared with 54 percent infested and 33 percent weevily at the time of the January, 1943 sampling. Fumigation, and the continued action of low grain temperatures were responsible for the reduction in infestation. A comparison of the infestation at the two storage sites since the establishment of the project is given in table 5.

Table 5:--Comparison of the insect infestation in wheat stored at Jamestown, North Dakota, and at Hutchinson, Kansas, October, 1941 to May, 1943.

Sampling period	Jamestown, North Dakota				Hutchinson, Kansas			
	No. bins sampled	Weevily bins (%)	Infested but not weevily (%)	Total infested (%)	No. bins sampled	Weevily bins (%)	Infested but not weevily (%)	Total infested (%)
1941								
Oct.-Nov.	139	1	18	19	144	9	31	40
1942								
Jan.-Feb.	133	1	6	7	135	16	53	69
Apr.-May	139	0	4	4	135	2	59	61
July-Aug.	142	0	6	6	124	0	43	43
Oct.-Nov.	146	0	1	1	133	58	21	79
1943								
Jan.-Feb.	152	0	0	0	144	33	21	54
Apr.-May	164	0	0.6	0.6	148	5	26	31

Six species of stored grain insects were found in the quarterly samples at Hutchinson, as listed below:

Species	Total number in 508 quarts examined
Flat grain beetle (Laemophloeus minutus Oliv.)	215
Rice weevil (Sitophilus oryza L.)	56
Sawtoothed grain beetle (Oryzaephilus surinamensis L.)	43
Lesser grain borer (Rhyzopertha dominica F.)	20
Red flour beetle (Tribolium castaneum Hbst.)	2
Cadelle larvae (Tenebroides mauritanicus L.)	1

* Reported by H. H. Walkden and R. B. Schwitzgebel, U. S. Bureau of Entomology and Plant Quarantine

Condition of wheat stored at Jamestown and at Hutchinson

At Jamestown there has been no change in the commercial grade of the wheat since the bins were filled two years ago.

At Hutchinson, the same situation exists except for four bins which graded sample grade because of odor. Three of these were graded down because of sour odor, probably due to insects, inasmuch as these bins were weevily in October, 1942; the fourth bin is in the experimental floor series and moisture leaks were responsible for the musty condition of the grain near the floor, the odor being imparted to the average samples submitted for grading.

Thus after two years of storage, there has been practically no change in the commercial grade in upwards of 600,000 bushels of wheat in experimental storage at Jamestown and Hutchinson.

Observations on the Condition and Insect Infestation of Wheat Stored in 1000-bushel Bins with Different Types of Floor, Jamestown, North Dakota, and Hutchinson, Kansas.

After 22 months of storage, one of each of the 15 pairs of bins with different types of floor was emptied in order to observe the condition of the wheat next to the floor. The various floor types consisted of one perforated metal floor, 5 solid steel floors, 7 concrete floors with different treatments, one single-board floor, and one double-board floor. The wheat was removed in layers, and samples were taken near the floor from each bin.

The amount of caked and damaged grain found on the different types of floor varied considerably. In some of the bins a quantity of caked wheat was found on the floor belowwall and roof leaks. in others, the caked grain on the floor was found in a ring entirely around the bin next to the wall, and in some cases this ring was as much as two feet wide. These rings of damaged grain were apparently caused by water entering the bin at the floor-wall joint, as in many of these joints the caulking was defective.

The amount of damaged wheat caused by the floor itself was greatest in those bins having concrete floors. The concrete floor without treatment, and the one overlaid with inch boards were completely covered with caked grain. The amount of damaged grain was negligible in the bins with concrete floors treated with hot asphalt, or covered with moisture-proof paper.

In those bins having steel floors the damaged wheat was confined to a ring at the junction of the floor and wall.

As a result of these observations it appears that any type of solid or perforated bin floor is satisfactory if it is supported off the ground to provide a well ventilated air space. When the bin floor is laid either directly on the soil or over some fill material that may become damp, it is essential that both the floor and all floor seams be constructed so as to be moisture-tight to prevent ground moisture from reaching the grain.

At Hutchinson, as the bins were emptied, observations were made on the insect infestation in the damaged grain on the floors and side walls. Flat grain beetles were found in these areas in all parts of the bins where damaged grain occurred. The lesser grain borer was found only near the south wall. Under the conditions of these tests, it is evident that both the flat grain beetle and the lesser grain borer are able to survive the winter in 1000-bushel bins of wheat at Hutchinson, Kansas.

Field Study of the Condition of Wheat Stored in Commodity Credit Corporation Bins in the Hard Winter and Spring Wheat Regions.

During April, a field study was made of the condition of wheat stored in Commodity Credit Corporation bins in the states of Oklahoma, Texas, Kansas, and Nebraska; and late in May several sites in North Dakota were observed. In selecting bins for study, the bin records in the County AAA offices were examined and an attempt was made to select several bins which represented both the best and worst conditions in that locality. This method was employed in order to make the best use of the limited time available for the study. In this way, the condition of both normal and heavily infested grain could be observed. The results are summarized in table 6 and include 3 bins of barley.

The heaviest infestations were encountered in the southern portion of the area, e. g., Oklahoma, Texas, and Kansas, and even in those areas, only a small percentage of the total volume of wheat in storage had become seriously infested. In most cases this wheat had been removed from elevator storage and placed in the CCC bins. It is believed that much of this trouble could have been averted if the grain had been fumigated immediately after the bins were filled.

The most abundant species of stored grain insects were the rice weevil, lesser grain borer, red flour beetle, and flat grain beetle. The list of the species together with their comparative abundance in the various localities is given in table 7.

Table 6:--Summary of survey of the condition of wheat stored in Commodity Credit Corporation bins in the hard winter and spring wheat regions.

Note: Rice weevil, granary weevil, and lesser grain borer are included under heading "weevils" in table 6; all others under "bran bugs". The mean temperature is the average of several readings in different parts of the bins.

Locality	Bin No.	Capacity (bu.)	Construction	No. insects per 1000 grams: Weevils	No. insects per 1000 grams: Bran bugs	Temperatures: Max.	Temperatures: Min.	Temperatures: Mean	Remarks
Oklahoma									
Blaine County, O'Keene	2	2700	Wood	56	129	73	51	58	Surface crusted NW quarter
	5	"	"	0	2	61	45	52	Surface OK
	8	"	"	6	23	63	44	56	Surf. crusted
	9	"	"	52	150	87	53	65	" " Heating
	11	"	"	30	22	90	45	69	Surf. crusted SW quarter Heating
Woods County, Alva	7	"	"	23	12	64	47	56	Crusted S. 1/3
	8	"	"	0	0	57	44	50	Surface OK
	10	"	"	12	7	79	46	57	Surf. crusted So. center Heating
Texas County, Guymon	4	2740	Steel	0	0	55	48	52	Surface OK
	6	"	"	0	0	56	54	55	" "
	8	2000	"	0	0	54	49	51	" "
Bakersburg	6	2740	Wood	7	40	92	54	80	Heating
	7	"	"	11	33	98	60	84	"
	8	"	"	0	21	91	56	74	Surf. crusted Heating
	11	"	"	0	0	49	45	47	Surface OK
Texas									
Deaf Smith Co., Hereford	3	1700	"	0	0	59	47	53	Surface OK
	4	"	"	0	0	58	48	52	" "
	6	"	"	0	0	57	49	52	" "
Dawn	1	2000	Steel	59	7	90	58	72	Heating; many rice weevils on surf. S. half
	2	"	"	42	30	75	50	57	Surf. crusted rice weevils on surface
Armstrong Co., Claude	3	1600	Wood	0	0	60	44	51	Surface OK
	4	"	"	0	0	56	48	53	" "
	6	"	"	0	0	57	50	53	" "
	17	1800	"	0	0	57	46	52	" "
	27	1600	"	0	2	54	46	50	" "

(Continued)

Table 6 (continued)

Locality	Bin No.	Capacity (bu.)	Construction	No. insects per 1000 grams: Wee-vils	Bran bugs	Temperatures: Max.	Min.	Mean	Remarks
Kansas									
Cloud County,	404	2000	Steel	0	0	51	42	46	Surface OK
Glasco	405	"	"	0	0	57	45	51	" "
	422	"	"	0	0	71	44	55	" "
Rooks County,	113	"	"	0	0	55	45	50	" "
Palco									
Plainville	218	"	"	0	0	56	45	51	" "
	408	"	"	0	0	55	45	49	" "
	410	"	"	0	0	53	45	48	" "
	424	2740	"	0	0	54	46	50	" "
	425	"	"	0	0	54	44	48	" "
Thomas County,	204	2000	"	0	0	53	40	45	" "
Colby	218	2740	"	0	0	57	44	50	" "
Mingo	705	2000	"	0	0	57	45	51	" "
	713	2740	"	0	0	57	49	54	" "
	716	"	"	0	0	60	45	50	" "
Wichita, Co.,	227	2000	"	0	23	91	68	85	Surf. firm
Leoti									Heating
	236	"	"	0	0	60	45	52	Surface OK
	251	2800	Wood	0	0	57	37	46	" "
	244	2900	"	31	29	83	52	71	Surf. crusted
									SW quarter
	243	"	"	0	0	50	40	44	Surface OK
Ford County,									
Bellefont	110	2000	Steel	21	32	85	48	62	Top ft. caked
									entire surf.
									Heating
Wright	947	"	"	0	0	58	46	52	Surface OK
	952	2700	Wood	0	0	57	43	50	" "
Dodge City	466	2900	"	9	14	76	55	59	Surface OK;
									heating 3'
									above floor
	493	2400	"	0	0	57	45	50	Surface OK
	516	"	"	52	162	102	64	88	Surf. caked
									and moldy;
									heating
Barton County,									
Claflin	201	2000	Steel	0	11	54	46	49	Surface OK
	203	"	"	0	38	53	50	51	" "
	204	"	"	0	13	50	46	48	" "
	205	"	"	0	2	52	46	49	" "

(Continued)

Table 6 (continued)

Locality	Bin No.	Capacity (bu.)	Construction	No. insects per 1000 grams: Weevils	Bran bugs	Temperatures: Max.	Min.	Mean	Remarks
Nebraska									
Webster County	1	2000	Steel	0	9	49	42	46	Surface OK
Bladen	3	"	"	0	1	51	42	46	" "
	7	"	"	0	0	54	44	49	" "
	8	"	"	0	0	54	43	49	" "
	9	"	"	0	2	46	43	45	" "
Hitchcock Co.	2	"	"	0	11	57	47	50	Moldy grain
Trenton									below ventilator
	3	"	"	0	2	56	49	51	Ditto
	23	"	"	0	1	57	45	51	Ditto
	25	"	"	0	0	57	47	51	Surface OK
	26	"	"	0	1	58	47	51	Moldy grain
									below ventilator
Cheyenne Co.	1	"	"	0	1	53	42	46	Surface OK
Sidney	20	2740	"	0	0	55	44	49	" "
Box Butte Co.	13	2000	"	0	1	51	35	42	" "
Berea	18	"	"	23	516	73	43	57	Barley, surf. moldy
	28	"	"	6	13	--	--	--	" " "
	30	"	"	11	37	--	--	--	" " "
North Dakota									
Stutsman Co.	Y-2	2400	Wood	0	0	55	40	48	Surface OK
Jamestown	Y-3	"	"	0	0	54	42	48	" "
	O-2	2740	Steel	0	0	59	31	40	" "
	O-3	"	"	0	0	57	31	40	" "
Morton County	1	2400	Wood	0	mites	55	38	46	" "
New Salem	2	"	"	0	"	59	39	49	" "
	6	"	Steel	0	"	58	38	47	Wet, moldy under
									E manhole
	9	2740	"	0	"	62	34	44	Surface OK
Ward County	5	2000	"	0	"	54	32	38	" "
Berthold	6	"	"	0	"	52	33	42	" "
	9	"	"	0	"	52	35	42	" "
	10	"	"	0	9	59	33	45	" "
					mites				
Ramsey County	B-7	"	"	0	1	57	34	44	" "
Church's					mites				
Ferry	B-8	"	"	0	"	60	36	46	" "
	B-9	"	"	0	"	56	36	43	" "

Table 7:--Summary of stored grain insects found in stored wheat and barley in hard winter and spring wheat region, April, 1943

Location	Rice weevil Sitophilus oryza L.	Granary weevil Sitophilus granarius L.	Lesser grain borer Rhyzopertha dominica F.	Sawtoothed grain beetle Oryzaephilus surinamensis L.	Flat grain beetle Laemophloeus minutus Oliv.	Rust-red grain beetle Laemophloeus ferrugineus Steph.	Red flour beetle Tribolium castaneum Hbst.	Long-headed flour beetle Latheticus oryzae Waterh.	Foreign grain beetle Ahasverus advena Waltl.	Hairy fungus beetle Typhaea stercorea L.	Cadelle Tenebroides mauritanicus L.
	(Average number per 1000 grams of grain examined)										
Oklahoma											
Blaine County	5	0	32	0.5	41	0	7	34	0.7	0	0
Woods County	5	0	9	0.8	5	0	2	0	0	0	0
Texas County	0	0	4	0.2	6	0	9	5	0	0	0
Texas											
Deaf Smith Co.	29	0	0	0	8	0	0	0	0	0	0
Armstrong Co.	0	0	0	0.2	0.2	0.2	0	0	0	0	0
Kansas											
Cloud County	0	0	0	0	0	0	0	0	0	0	0
Rooks County	0	0	0	0	0	0	0	0	0	0	0
Thomas County	0	0	0	0	0	0	0	0	0	0	0
Wichita County	15	0	0	4	2	0	12	0	0	0	0
Ford County	7	0	16	1	21	0	41	0	0.1	0	0.3
Barton County	0	0	0	10	4	0	0.2	0	0	0	0
Pratt County	15	0	18	0	35	0	32	16	0	0	0
Nebraska											
Webster County	0	0	0	0.3	2	0	0	0	0	0	0
Hitchcock Co.	0	0	0	0.3	3	0	0	0	0	0	0.3
Cheyenne Co.	0	0	0	0	0.3	0	0	0	0	0	0
Box Butte Co.	0.1	11	0	0	0	81	39	0	33	6	
North Dakota											
Stutsman Co.	0	0	0	0	0	0	0	0	0	0	0
Morton County	mites	0	0	0	0	0	0	0	0	0	0
Ward County	mites	0	0	0.3	0	2	0	0	0	0	0
Ramsey County	mites	0	0	0	0	0.3	0	0	0	0	0

Sampling Methods

Infestation data for the bins at Jamestown and Hutchinson have been based on the number of insects found in an average sample taken from 10 places in the bin. Experience has shown that at certain times of the year, particularly in late fall and winter, the insects tend to concentrate in the south quarter of the bin. Quite frequently other portions of the grain are relatively free from infestation, with the result that an average or composite sample taken from 10 places in the bin may blot out heavily infested spots. In an effort to determine the influence of compositing, the several sub-samples were examined separately when the regular quarterly sampling was being done at Hutchinson during April. A total of 57 bins were sampled in this manner, 31 of which were infested. It was found that 80.5 percent of the insects were in the upper half of the bin, with the greatest numbers occurring in the center. In the lower half of the bins, the greatest numbers of insects were found in the south quadrant. Thus it would appear that during April and early in May, sampling in the upper half of the center of the bin is most likely to reveal insect infestation. Sampled in the manner noted above, 31 of the bins were found to be infested while 12 of them showed no infestation, based on the examination of the average (composite) samples. However, none of these were heavily infested. The results of these samplings are given in table 8.

Table 8:--Quarterly sampling, Hutchinson, Kansas, April, 1943. Results of separate examination of 10 probes comprising the average sample.

Bin No.	Numbers of insects per 1000 grams (Location of sub-sample)												Total	Average Sample
	Center		North		East		South		West		Totals			
	Upper	lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower		
5-1	3		2				1	6	3		9	6	15	3
6-2	1			9			3		1		5	9	14	2
5-2				1				1			0	2	2	0
11-10						1					0	1	1	0
3-10	1		1				3				5	0	5	1
3-11					1		1				2	0	2	1
7-2	1							2			1	2	3	1
8-1							3	1			3	1	4	1
4-10	1										1	0	1	0
2-12	1				3			3	5	2	9	5	14	3
3-12	3	1	1				1	1			5	2	7	3
9-5	6					4	3		1	1	10	5	15	2
5-10	2	1							1		3	1	4	1
6-12	7				50						57	0	57	7
3-13		1	1								1	1	2	1
4-12			1								1	0	1	0
5-7							1			1	1	1	2	0
5-8	4						1	13		1	5	14	19	3
2-15							1				1	0	1	0
11-8	1								1		2	0	2	0
3-14							1				1	0	1	0
3-15								1			0	1	1	0
6-3										1	0	1	1	0
6-8	1		1		1		1				4	0	4	1
9-6						1					0	1	1	0
10-5							8	2			8	2	10	1
11-2	45					1		8	1		46	9	55	7
12-1	8			1	1		6	1			15	2	17	2
5-11			30		1		33		4		68	0	68	9
12-11							1				1	0	1	0
8-8	2		1		5		1				9	0	9	1
	87	3	38	11	62	7	69	39	17	6	273	66	339	

Experimental Fumigation of Wheat and Corn

Experimental fumigation of wheat and corn has been continued during the past quarter. Tests with carbon tetrachloride alone and various mixtures of carbon tetrachloride, with carbon disulphide, chloropicrin, ethylene dichloride, and propylene dichloride have been conducted at Ames, Iowa, and Hutchinson, Kansas. The results of the tests made at Hutchinson are given in table 9 and those at Ames are tabulated in table 10.

From the tests with carbon tetrachloride alone it appears that this material is an effective fumigant when applied at dosages of 3 to 4 gallons per 1000 bushels of grain. Further tests in heavily infested bins are planned to determine its efficiency under such conditions.

The mixture of carbon disulphide 20%, carbon tetrachloride 80%, performed well at dosages as low as 2 gallons per 1000 bushels in steel bins, in grain with a moisture content below 12 percent. In wood bins, 4 gallons of the mixture was required to produce kills approaching 100 percent.

The mixture containing 75% ethylene dichloride and 25% carbon tetrachloride failed to give good kills in grain of 5% dockage, even at a dosage of 8 gallons per 1000 bushels. In wood bins containing low dockage wheat more than 5 gallons per 1000 bushels would be required.

In corn, propylene dichloride 75%, carbon tetrachloride 25%, gave poorer kills than carbon tetrachloride alone.

The results with chloropicrin indicate that 1-1/2 pounds in 1 gallon of carbon tetrachloride applied at the rate of 2 gallons of the mixture per 1000 bushels will give good kills, while 2 pounds of chloropicrin in 1 gallon of carbon tetrachloride, applied at the rate of 1 gallon of the mixture in 1000 bushels is insufficient to give perfect kills. Some difficulty was experienced in getting an even distribution of the fumigant when lower dosages were applied.

From these tests it appears that high dockage grain, and grain of high moisture content require greatly increased dosages for effective fumigation. Also, the dosages established for tight steel bins are not applicable to wooden bins, the latter requiring heavier dosages. Further tests in wooden bins are necessary to determine the proper amount of fumigant for this type of bin.

Table 9:--Results of experimental fumigation of wheat, Hutchinson, Kansas

Fumigant	Bin No.	Capacity (bu.)	Date treated	Dosage per 1000 bu. (gals.)	Mortality (%)	Mortality (%) Control	Remarks
Carbon bisulphide, alone	8-7	2740	3/20	2	99	11	Steel bins except as noted.
	7-7	"	"	1	99	11	
Carbon bisulphide 20% carbon tetrachloride 80%	½-P-1	1000	6/9	4	100	23	13% moisture grain.
	½-P-2	"	"	3	100	23	Incomplete kill in natural
	9-11	2740	6/15	3.5	100	3	population.
	9-10	"	"	3	100	3	
	10-10	"	"	3	100	3	
	2-4	1000	6/22	2	100	24	
	2-5	"	"	2	100	24	
	13-3	1500	"	3	95	24	Wood lined with Kraft paper.
	13-4	"	"	3	98	24	" " " " "
	13-5	"	"	4	97	24	Wood, no lining.
	13-6	"	"	4	99	24	" " "
Carbon tetrachloride, alone	1-1	1000	5/6	5	100	14	
	1-4	"	"	4	100	14	
	2-13	"	"	3	99	14	
	½-P-1	"	5/28	3	67	14	Poor kill in native popula-
							tion. 13.2% moisture grain.
	½-P-2	"	"	3	72	14	" " "
	3-17	1250	"	3	100	14	11.5% " "
	5-11	4000	"	3	92	14	2000 bu. removed before
							fumigation. 12.5% moisture.
	10-9	2740	6/15	3	100	3	
	12-9	"	"	3	100	3	
	11-7	"	"	3	99	3	
	6-12	5000	5/28	3	100	14	12% moisture grain.

(continued)

Table 9 (continued)

Fumigant	Bin No.	Capacity (bu.)	Date treated	Dosage per 1000 bu. (gals.)	Mortality (%)	Mortality (%) Control	Remarks
Coop-02 (ingredients not known)	9-12	2740	4/28	2	99	18	
	10-11	"	"	2	100	18	
Ethylene dichloride 75% carbon tetrachloride 25%	12-5	"	5/3	8	83	20	5% dockage in grain.
	12-3	"	"	6	78	20	" " " "
	13-10	1500	"	5	70	20	Wood bin.
	13-11	"	"	5	67	20	" "
	13-1	"	"	4	60	20	" "
	13-2	"	"	4	53	20	" "
	4-10	1000	5/28	4	97	10	After turning and cleaning.
	4-11	"	"	4	100	10	" " " "
Chloropicrin 1½ lbs. carbon tetrachloride 1 gal.	2-13	1000	6/12	2	100	28	2 gals. mixture per M bu.
	3-4	"	"	2	100	28	" " " " " "
Chloropicrin 2 lbs. carbon tetrachloride 1 gal.	½-6	1000	6/12	1	86	28	1 gal. mixture per M bu.
	1-4	"	"	1	81	28	" " " " " "
	1-16	"	"	2	100	28	2 " " " " " "
	2-16	"	"	2	100	28	" " " " " "
Chloropicrin 3 lbs. Carbon tetrachloride 1 gal.	8-12	"	"	1	100	28	1 gal. mixture per M bu.
	9-13	"	"	1	100	28	" " " " " "

Table 10:--Results of experimental fumigation of corn, Ames, Iowa, May, 1943.

Fumigant	Bin No.	Capacity (bu.)	Date treated	Dosage per 1000 bu. (gals.)	Mortality (%)	Mortality (%) Control	Remarks
Ethylene dichloride 75%, carbon tetrachloride 25%	299	2740	5/14	4	95	24	Steel bins.
	47	2000	5/14	4	100	24	
Propylene dichloride 75%, carbon tetrachloride 25%	414	2740	5/14	4	93	24	
	41	2000	5/14	4	81	24	
Carbon tetrachloride alone	300	2740	5/14	4	95	24	
	46	2000	5/14	4	92	24	

Retention of Fumigants in Grain Stored in Steel Bins

Observations in two bins fumigated with carbon bisulphide showed that the gas is retained in killing concentrations even after the grain is turned into another bin. The data are given in table 11. It may be noted that the initial kill at both dosages is nearly the same, but that after turning the grain, the grain in the bin receiving the higher dosage retained enough gas to give as good a kill as in the original fumigation. The results of this test emphasize the hazard in moving grain too soon after fumigation, especially if it has been fumigated with an explosive fumigant such as carbon bisulphide.

Table 11:--Retention of carbon bisulphide in grain fumigated March 20, 1943.

	Bin No. 7-7 (2740 bu.)	Bin No. 8-7 (2740 bu.)
Dosage, carbon bisulphide, per 1000 bu.	1 gal.	2 gals.
Mortality in check boxes before moving grain:		
9 ft. above floor	98%	98%
6 " " "	98%	100%
3 " " "	98%	100%
Floor	100%	100%
Average	98.5%	99.5%
Control mortality	11%	11%
Grain turned into another bin March 23, 1943, and check probes inserted on March 24; removed 3 days later, March 27.		
Mortality in check probes after turning grain:		
9 ft. above floor	63%	98%
6 " " "	55%	100%
3 " " "	47%	98%
Floor	15%	100%
Average	45%	99%
Control mortality	12%	12%

Effect of Fumigation on the Viability of Wheat Stored in Tight Steel Bins.

Mention has been made in previous reports of the effect of fumigant mixtures containing methyl bromide on the germination of the grain. In an effort to determine the effect of such fumigants in different portions of the grain stored in steel bins, a series of four 2740-bushel bins and four 1000-bushel bins were sampled and the viability of the grain at levels of 3, 6, 9, and 12 feet above the floor was determined. These bins had been fumigated twice with a mixture containing 10 percent methyl bromide. The results are summarized in table 12. The reduction in viability was greater in the 2740-bushel bins than in those of 1000-bushel capacity, and this reduction was more pronounced in the upper portions of the grain.

Table 12:--Effect of fumigation on viability of wheat stored in tight steel bins, Hutchinson, Kansas. Bins fumigated with mixture containing 10% methyl bromide.

2740-bushel bins (% germination)				1000-bushel bins (% germination)			
Location of sample	Distance above floor	Fumigated (Ave. of 4 bins)	Control (unfumigated)	Location of sample	Distance above floor	Fumigated (Ave. of 4 bins)	Control (unfumigated)
Center	12'	43	96	Center			
	9'	52	96				
	6'	84	96		7'	46	78
	3'	83	96		4'	79	88
	Floor	88	96		Floor	88	89
	Average	70.0	96.0			71.0	85.0
4 ft. from East wall	12'	44	91	4 ft. from West wall			
	9'	51	94				
	6'	83	96		7'	54	79
	3'	85	93		4'	80	87
	Floor	78	96		Floor	87	86
	Average	68.2	94.0			73.7	84.0
1 ft. from East wall	12'	38	92	1 ft. from West wall			
	9'	44	98				
	6'	71	96		7'	54	76
	3'	75	96		4'	83	88
	Floor	82	96		Floor	72	54
	Average	62.0	95.6			69.7	72.7

Tests with Various Treatments of Wooden Grain Bins to Prevent Burrowing of Grain Infesting Insects*

The model wooden bins included in this test have now been subjected to attack by grain-infesting insects for 1 year. As shown by the data of table 11 several treatments have proved to be highly effective in protecting the woodwork of the bins from attack. Of two bins treated with a fly spray concentrate composed of secondary terpene-alcohol thiocyanyl acetate, one remained entirely free from damage during the entire year, whereas the other sustained damage to the extent of one small hole. Of two bins painted on the inside with white lead paint both were found to have two small holes bored in the woodwork.

Other materials that prevented material damage to the woodwork of the bins for the entire year were white wash and a 40% solution of nicotine sulphate.

From the standpoint of economy and efficiency it would seem probable that a yearly coat of white wash would be the simplest procedure for the treatment of wooden bins for farm stored grain.

Field tests are now being conducted with a number of the more promising treatments.

Table 11:--Condition of wooden bins after one year's exposure to attack by the cadelle and lesser grain borer.

No.	Treatment of bin	Number of holes bored in woodwork after 1 year
1	White lead paint, 2 coats	2
2	do	2
11	Dow Spray 208, 2 coats	5
12	do	10
15	Lethane 384, 2 coats	7
16	do	9
17	Nicotine sulphate 40%, 1 coat	6
18	do	5
19	Thanite special, 2 coats	1
20	do	0
23	White wash, 1 coat	5
24	do	7
35	White paint + 10% nicotine sulphate 40%	7
36	do	8

Dow Spray 208 = 5% in deobase oil of a 50% concentration of phenothioxene in methylene chloride.
Lethane 384 = a 50% solution of n-butyl carbitol thiocyanate in kerosene.
Thanite = Secondary terpene-alcohol thiocyanyl acetate.

* Reported by R. T. Cotton in cooperation with Mr. H. D. Young, Division of Insecticide Investigations.

Effect of Grain Moisture on the Survival, Reproduction, and Development of Stored Grain Insects.*

In a previous report results on the survival of stored grain insects in 12, 13, and 14% moisture wheat held at a constant temperature of 65° F., were listed and a statement to the effect that no reproduction had been observed at the time the report was written. Due to the fact that the out-door temperatures were too high to maintain a constant temperature as low as 65° F. this series had to be discontinued after a run of eleven weeks. As in all of our tests, the wheat in the granary and rice weevil cultures is changed every two weeks and the infested wheat is incubated at the same temperature as the culture chamber until emergence of progeny is completed. Due to the slow rate of development of insects at 65° F., the infested wheat removed from the cultures held at 65° F. was placed in a constant temperature chamber of 80° F.

No progeny were recovered from the wheat exposed to the granary weevil. In the case of the wheat exposed to the rice weevil, progeny were recovered from all three moisture variants. The total number of progeny recovered was for 12% wheat, 731; for 13% wheat, 583; and for 14% wheat, 1194.

* Reported by R. T. Cotton and J. C. Frankenfeld

Effect of Grain Moisture on the Survival, Reproduction and Development of Stored Grain Insects.*

Continuing our studies on the effect of moisture and temperature on the development of our common stored grain insects, a series of cultures was started using wheat with moisture variants of 12, 13, and 14% at constant temperatures of 80 and 85°F. As in previous tests the same six species of stored grain insects, as listed in tables 12 and 13 were used. The results of biweekly examinations on the survival and rate of reproduction of these insects are given in tables 12 and 13. Again as in our previous tests, the percentage of survival, at a given constant temperature, increases as the moisture content of the wheat is increased. This is true, although in variable degree, for all six species of insects used in these tests.

Comparison of the percentage of survival in cultures at constant temperatures of 80° F. with the survival in cultures held at 85° F. seems to indicate that, for four of the species of insects used, a constant temperature of 85° F. is less favorable than a constant temperature of 80° F. for all three moisture variants. Although the percentage of survival of the granary weevil is slightly reduced for each moisture variant at a constant temperature of 85° F. as compared with a constant temperature of 80° F., the difference except in the 14% moisture wheat is not significant. In case of the rust red flour beetle there is no difference in the percentage of survival at the two temperatures.

For most of the species of stored grain insects included in these tests, reproduction at 80 and 85° F. follows the same pattern as the percentage of survival. That is, as the moisture content of the wheat increases the greater is the number of progeny that are produced. The numbers of progeny recovered for each species are listed in the last column of tables 12 and 13. In the case of the granary and rice weevils these figures are not complete, the figures listed represent the total number of progeny recovered from wheat infested during the first seven weeks of exposure. It will be noted that the number of progeny recovered shows a definite and significant increase with each increased moisture variant. Thus, 4,569 granary weevil were recovered from wheat with a moisture content of 12%, at 80° F., 6,791 from 13% wheat, and 8,105 from 14% wheat. At 85° F. the number of progeny recovered for the 12, 13, and 14% moisture wheat was 3,687, 5,382, and 5,908 respectively. The reduction in the number of progeny recovered in the 85° F. as compared with the 80° F. series is in keeping with the idea stated in the discussion on the percentage of survival, namely that at 85° F. we are approaching a temperature less favorable for the development of the granary weevil.

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* Reported by R. T. Cotton and J. C. Frankenfeld.

Table 12:--Survival of various species of stored grain insects reared in 12, 13, and 14% wheat at 80° F.

Species of Insect	Percentage survival after 1 Week	3 Weeks	5 Weeks	7 Weeks	9 Weeks	11 Weeks	13 Weeks	15 Weeks	Number of progeny recovered
12% Wheat									
Granary weevil	100	96	96	95	83	80	74	58	4569
Rice weevil	100	94	94	87	86	85	83	69	9164
Confused flour beetle	100	92	92	92	88	85	83	81	37
Sawtoothed grain beetle	100	99	94	75	52	28	19	16	278
Rust red flour beetle	100	100	100	99	92	89	89	85	50
Lesser grain borer	100	94	12	6					373
13% Wheat									
Granary weevil	98	98	98	96	93	92	89	76	6791
Rice weevil	97	97	97	71	70	68	59	45	9341
Confused flour beetle	94	92	91	88	87	85	84	83	43
Sawtoothed grain beetle	100	96	89	65	49	40	31	23	550
Rust red flour beetle	100	100	100	100	100	98	98	98	135
Lesser grain borer	98	97	97	96	96*				419
14% Wheat									
Granary weevil	99	99	99	96	93	92	85	81	8105
Rice weevil	97	95	95	58	37	36	36	33	12100
Confused flour beetle	93	93	91	91	90	89	88	86	53
Sawtoothed grain beetle	100	96	88	71	59	50	40	28	503
Rust red flour beetle	99	99	99	99	99	99	99	99	84
Lesser grain borer	100	100	100	99	94	94*			367

* Date first progeny were recovered.

Table 13:--Survival of various species of stored grain insects reared in 12, 13, and 14% wheat at 85° F.

Species of Insect	Percentage survival after 1 Week	3 Weeks	5 Weeks	7 Weeks	9 Weeks	11 Weeks	13 Weeks	15 Weeks	Number of progeny recovered
12% Wheat									
Granary weevil	97	97	97	95	91	85	80	55	3687
Rice weevil	97	96	96	20	20	20	19	17	4994
Confused flour beetle	96	89	86	79	74	74	68	61	67
Sawtoothed grain beetle	98	90	63	11	11	6	5	5	520
Rust red flour beetle	100	100	100	97	97	97	94	92	42
Lesser grain borer	100	100	100	100	81*				574
13% Wheat									
Granary weevil	98	97	93	90	90	88	84	74	5382
Rice weevil	97	96	94	18	12	11	11	10	6058
Confused flour beetle	97	94	91	62	62	61	58	53	86
Sawtoothed grain beetle	100	94	73	26	21	19	18	17	781
Rust red flour beetle	99	99	99	98	97	97	97	96	158
Lesser grain borer	98	30	30	8	8*				135
14% Wheat									
Granary weevil	95	95	95	92	84	84	80	71	5908
Rice weevil	96	95	95	10	2	0	0	0	5983
Confused flour beetle	95	90	89	64	62	59	57	57	52
Sawtoothed grain beetle	99	93	85	22	22	22	22	21	1103
Rust red flour beetle	100	100	100	100	100	100	100	99	114
Lesser grain borer	100	98	98	83	83*				281

* Date first progeny were recovered.

In tests previously conducted using wheat with the same moisture variants but at temperatures of 70 and 75° F., we noted that the granary weevil apparently preferred wheat with a moisture content of 13%. Results of the tests herewith reported seem to indicate that when the temperature is 80 or 85° F., the higher the moisture content of the wheat the more favorable are the conditions for reproduction as well as for survival of the adults.

In all of our tests with the rice weevil, the numbers of progeny recovered increases with the increase in moisture content of the wheat. This same relationship holds true for the three moisture variant wheats in the tests at 80 and 85° F. At 80° F. the number of progeny recovered in 12, 13, and 14% moisture wheat was 9,164, 9,341, and 12,100 respectively; and at 85° F. the number of progeny recovered was 4,994, 6,058, and 5,983 respectively. Here again a decided decrease is noted in the 85° F. cultures as compared with the 80° F. cultures. Since, as was stated above the number of progeny recovered represents only the progeny from wheat infested during the first seven weeks, this difference is unquestionably due to unfavorable conditions of moisture and temperature rather than to the greater mortality obtained in the 85° F. series. It should be noted that there was very little difference in the percentage of survival for the various lots prior to the 7th week examination.

The percentage of survival of the confused flour beetle varied only slightly in the moisture variants at a given temperature. At 80° F. the percentage of survival in 12, 13, and 14% moisture wheat was 81, 83, and 86% respectively, and at 85° F. the percentage of survival was 61, 53, and 57% respectively. These differences in the percentage of survival in the lots within a given temperature series are not significant. The differences noted between the lots held at 80° F. and those at 85° F. are significant and indicate less favorable conditions existing at 85° F. than at 80° F. for this insect.

From the standpoint of reproduction we find the same relationship exists as was true of the granary and rice weevil, namely that as the moisture content is increased we have a correlated increase in rate of reproduction. Furthermore, there was a considerable increase in the 12 and 13% wheat at 85° F. as compared with the same lots at 80° F. Since reproduction of the confused flour beetle in wheat is more or less dependent upon the amount of dockage in the wheat, and since these tests are started with clean wheat and therefore the amount of dockage is dependent upon the ability of the adult beetles to "mill" the wheat, it is clearly seen that the higher the moisture content the more easily can the wheat be attacked by the beetle. Then, too, wheat with a given moisture content becomes softer as the temperature rises, thus making it more easily accessible for adult beetle feeding, which results in a higher production of dockage, thereby creating better conditions for the young larvae to develop.

The decrease in production of progeny in the 14% moisture wheat at 85° F. as compared with that found in the 12 and 13% wheat is probably due to the effect of mold upon the eggs. Fourteen percent wheat becomes musty very quickly when exposed to 85° F. or above.

The rust red flour beetle seems to be able to adapt itself more readily to a variety of conditions in wheat than is true of the confused flour beetle. Although both species are closely related and both have similar habits, the rust red flour beetle is usually found in greater numbers in grain than is the confused flour beetle. In our tests the rust red flour beetle always has a higher percentage of survival, and a higher productive rate than does the confused flour beetle. Although not so pronounced as some of the other species, the percentage of survival increases as the moisture content of the wheat increases. There is little or no difference in the percentage of survival between the two temperatures of 80 and 85° F. In previous tests no reproduction by this species was obtained in 12, 13, and 14% wheat at temperatures of 75° F. or below. Although no data is available at present, this species probably requires dockage in wheat before the young larvae are able to develop.

The percentage of survival of the sawtoothed grain beetle increases as the moisture content of the wheat increases. The percentage of survival in 12, 13, and 14% wheat at 80° F. was 16, 23, and 28% respectively; and at 85° F. 5, 17, and 21%. Here again a reduction in survival is noted in the 85° F. as compared with the 80° F. series, indicating, as with the other species already discussed, that at 85° F. conditions for long life are not as favorable as at lower temperatures. From the standpoint of reproduction, the number of progeny recovered from adults of this insect increased with the increase in moisture content of the wheat, and also as the temperature was raised. In 12, 13, and 14% moisture wheat at 80° F. the number of progeny recovered was 278, 550, and 503 respectively; and at 85° F. 520, 781, and 1,103 respectively. Thus while this species showed a lower percentage of survival at 85° F., as compared with that at 80° F., still the greater increase in progeny more than overcomes the decrease in survival. A temperature of 85° F. is therefore considered more favorable for this insect.

The difficulty in the handling of the lesser grain borer interferes greatly in obtaining accurate and complete results. The adults burrow into and feed in the wheat berry, making it difficult without cracking the wheat berry, to ascertain the percentage of survival. The larvae also feed within the berry, pupate therein, and the resulting adults emerge only to mate, and then return to feed and oviposit within the berry. In making our survival determinations, we depend upon the number of dead adults which are removed by sifting the grain over a 10-mesh screen. The adults apparently leave the wheat berry before dying, or else the dead adults are readily shaken out of the berry by sifting. The recovery of

progeny present a much more difficult problem especially when there happens to be a relatively high percentage of survivall of the original adults. As soon as the number of adults recovered, by sifting the grain, is seen to be greater than was obtained in the previous examination, all adults are removed and the number exceeding the number that survived at the previous examination plus the number removed in later examinations are recorded as progeny. The results therefore do not give a true picture of the effect of different moisture variants or temperature on this insect, but serve merely as an indication. To thoroughly study this insect different methods than are used with the other insects will have to be used.

Effect of Moisture and Temperature on the Reproduction of the Granary and Rice Weevils.*

In the quarterly report covering the period of January through March, 1943 for this station the effect of rearing granary and rice weevil in 12, 13, and 14% wheat at 70 and 75° F. was discussed. Due to the fact that reproduction records were incomplete at the time that report was being prepared, detailed account of this phase of the work was not completely covered.

Tables 14 and 15 give a record of the number of progeny produced by the granary and rice weevil over a period of 19 weeks. In obtaining progeny records for these two species of insects, 300 grams of wheat of the required moisture content are exposed to the adult weevils for a period of 2 weeks, after which the wheat is removed and kept in pint mason jars until emergence of progeny is completed.

Examining the records of the emergence of granary weevils it will be seen that in practically all of biweekly lots the number of progeny produced in the 13% moisture wheat was considerably greater than in either the 12 or 14% moisture wheat. This was true in both the 70 and 75° F. series. It remains to be seen whether this difference in reproduction was merely an accident or whether there is a definite moisture limit for a given range of temperature which is best suited for reproduction by this insect.

Another interesting feature was noted in the number of progeny produced by the granary weevil. At the end of the thirteenth week, our supply of wheat which was used in these tests was exhausted. Although we were able to obtain a new supply of the same variety, namely Tenmarq, it was practically 100% "yellow berry", which is in effect a softer wheat. In subsequent biweekly lots taken from both the 70 and 75° F. series the number of progeny was greatly increased. This again may be merely an accident, but the difference in the amount of reproduction between the two lots of Tenmarq wheat opens up another phase of study.

With the rice weevil, reproduction increases as the moisture content of the wheat and the temperature is increased. No significant increase is noted in the two lots of Tenmarq wheat as was true of the granary weevil.

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* Reported by R. T. Cotton and J. C. Frankenfeld.

Table 14:--Showing the reproduction of rice weevil in 12, 13, and 14% wheat at 70° and 75° F.

Moisture content of wheat	Number of progeny produced at 70° F. during: 1st Week	2nd, 3rd, 4th & 5th week	6th & 7th week	8th & 9th week	10th & 11th week	12th & 13th week	14th & 15th week	16th & 17th week	18th & 19th week	Total
12%	222	1575	646	419	391	139	658	423	354	4827
13%	444	2125	1374	1211	932	727	901	605	373	8692
14%	586	2341	1450	1427	1187	1010	1267	968	509	10745

Moisture content of wheat	Number of progeny produced at 75° F. during: 1st Week	2nd, 3rd, 4th & 5th week	6th & 7th week	8th & 9th week	10th & 11th week	12th & 13th week	14th & 15th week	16th & 17th week	18th & 19th week	Total
12%	47	1671	702	473	239	99	430	228	173	4262
13%	735	2911	1325	1152	868	587	785	585	296	9244
14%	744	3239	1608	1586	1308	1005	1183	1119	652	12444

Table 15:--Showing the reproduction of granary weevil in 12, 13, and 14% wheat at 70° and 75° F.

Moisture content of wheat	Number of progeny produced at 70° F. during: 1st Week	2nd, 3rd, 4th & 5th week	6th & 7th week	8th & 9th week	10th & 11th week	12th & 13th week	14th & 15th week	16th & 17th week	18th & 19th week	Total
12%	48	28	23	92	155	206	833	847	594	2826
13%	148	263	147	319	459	602	1166	1266	1147	5517
14%	153	125	44	137	245	285	466	1146	1044	3645

Moisture content of wheat	Number of progeny produced at 75° F. during: 1st Week	2nd, 3rd, 4th & 5th week	6th & 7th week	8th & 9th week	10th & 11th week	12th & 13th week	14th & 15th week	16th & 17th week	18th & 19th week	Total
12%	86	448	247	155	128	88	545	885	779	3361
13%	118	1202	349	267	184	177	510	849	780	4436
14%	114	712	144	149	156	95	209	472	537	2588

Effect of the Amount of Dockage on the Ability of Tribolium confusum to Survive and Reproduce in Wheat of Various Moisture Content.*

In a previous series of tests conducted to determine the effect of dockage in wheat on the ability of the confused flour beetle to survive, and reproduce, it was shown that the percentage of survival in dry wheat is definitely associated with the amount of dockage in the wheat. That is, in wheat with a moisture content of 8% the percentage of survival is increased proportionally with increased amounts of dockage. It was further shown that in wheat with a moisture content of 12% or more there was no significant difference in the percentage of survival in any of the dockage variant lots. But that in 12 and 14% moisture wheat the amount of reproduction increased with increased amounts of dockage. A deviation from the expected results, however, showed up in the 14% moisture series. Instead of an increased amount of reproduction over the 12% series, there was actually a decided decrease and in the higher dockage lots reproduction was practically nil. It was assumed that this lack of reproduction might be attributed to mold, which is very injurious to the eggs of the confused flour beetle. To confirm or disprove this assumption, a second series of tests was started using the same dockage variants, namely, 0.5, 1.0, 2.0, 4.0, and 8.0%, but changing the moisture variants. In this second series, wheat with moisture content of 9, 12, and 15% was used. Only adult confused flour beetles (50♀ and 50♂) freshly emerged, and which had had no opportunity to mate or oviposit, were used. This series of tests has been in progress for nine weeks and the results of weekly examinations are summarized in table 16. It will be noted that there is no significant difference in the percentage of survival in any of the dockage variants lots, either within a given moisture level, or between the three moisture variants. All show a very high percentage of survival.

From the standpoint of reproduction, however, we find a striking correlation between the different dockage variants in each moisture series. In each of the three moisture series, the number of progeny, recovered as pupae, increases with the increase in amount of dockage present in the culture media. Likewise, for each dockage variant, there is a correlated increase in the number of pupae recovered with the increase in the moisture content of the wheat. Table 16 summarizes the results of weekly examination showing the percentage of survival and the degree of reproduction.

The fact that such a high reproduction took place in the 15% moisture series disproves the assumption that molds may have retarded reproduction in the 14% moisture series referred to above.

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* Reported by R. T. Cotton and J. C. Frankenfeld.

Table 16:--Survival and reproduction of *T. confusum* in 9, 12, and 15% moisture wheat with ranging percentages of dockage at 80° F.

Rearing medium	Percentage of survival after 1 Week	2 Weeks	3 Weeks	4 Weeks	5 Weeks	6 Weeks	7 Weeks	8 Weeks	9 Weeks	Number of progeny
9% Moisture										
Clean whole wheat berries	100	98	98	98	98	98	97	96*	92	12
Same plus 0.5% dockage	98	96	96	96	96	95*	94	94	94	12
" " 1.0% "	98	98	98	98	98	98*	97	97	96	140
" " 2.0% "	98	93	92	92	92	92*	92	92	92	191
" " 4.0% "	96	95	93	93	93	93*	92	92	92	330
" " 8.0% "	99	98	98	98	96	96	96*	96	93	377
12% Moisture										
Clean whole wheat berries	99	98	98	98	98	98*	98	98	98	88
Same plus 0.5%dockage	98	98	98	97	97*	97	97	97	97	118
" " 1.0% "	100	96	96	96	96*	96	96	96	96	214
" " 2.0% "	99	98	98	98	98*	98	98	98	98	265
" " 4.0% "	100	97	96	96	96*	96	95	95	94	404
" " 8.0% "	100	100	100	99	99*	99	97	97	97	494
15% Moisture										
Clean whole wheat berries	100	99	99	99	99*	99	97	97	97	193
Same plus 0.5% dockage	99	99	98	98	97*	97	97	97	97	221
" " 1.0% "	95	95	94	93	93*	93	93	93	93	241
" " 2.0% "	99	99	98	98	98*	98	98	98	98	276
" " 4.0% "	99	98	98	98	98*	98	98	98	98	413
" " 8.0% "	97	94	94	94	94*	94	94	93	93	703

* Period first pupae were recovered.